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# Perceived Usefulness and Higher-Order Thinking: A PLS-SEM Investigation of the Chaoxing AI Learning Companion Platform among Vocational College Students

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**Abstract:** This study focuses on vocational college students' adoption of the "embedded" Chaoxing AI learning companion platform and the influence of AI learning companion adoption on higher-order thinking. Unlike general-purpose AI tools, the Chaoxing AI learning companion platform is embedded in institutional teaching platforms and course-based learning processes. However, existing research has largely examined willingness to use general-purpose generative AI tools, and empirical evidence on how AI learning companion functions embedded in educational platforms affect vocational college students' higher-order thinking remains scarce. Drawing on the Technology Acceptance Model (TAM), this study constructs a research model of "perceived ease of use and perceived usefulness—AI learning companion adoption—higher-order thinking" and conducts PLS-SEM analysis on 75 valid questionnaires using SmartPLS. The results show that the revised measurement model exhibits good reliability and convergent validity. The structural model results indicate that perceived usefulness significantly and positively affects AI learning companion adoption ($\beta = 0.748$, $P < 0.001$), whereas perceived ease of use does not significantly affect AI learning companion adoption ($\beta = 0.092$, $P = 0.517$); AI learning companion adoption significantly and positively affects higher-order thinking ($\beta = 0.540$, $P < 0.001$). The mediation results further show that AI learning companion adoption exerts a significant indirect effect between perceived usefulness and higher-order thinking ($\beta = 0.404$, $P = 0.001$), whereas the indirect effect of perceived ease of use is not significant. The findings suggest that, in the vocational education context, whether students perceive the AI learning companion as "genuinely useful" matters more for their adoption than whether it is "easy to use," and this adoption is further associated with the development of higher-order thinking. By applying TAM to platform-based AI learning companion scenarios, this study extends the model's explanatory scope to embedded educational agents and offers practical implications for vocational colleges to optimize AI-supported learning tools and promote more inclusive and sustainable education (SDG 4).

**Keywords:** Chaoxing AI learning companion platform; Higher-order thinking; Technology Acceptance Model; Perceived usefulness; PLS-SEM; SDG 4

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# 1. Introduction

In the past two years, attention to artificial intelligence in education has shifted rapidly from "whether it can be used" to "whether it can genuinely improve learning." Large language models represented by ChatGPT have triggered a new round of discussion on pedagogical transformation; subsequently, international products such as Gemini and Claude, as well as domestic large models and conversational applications such as ERNIE Bot (Wenxin Yiyan), Qwen, iFlytek Spark, Kimi, and Doubao, have continued to enter students' daily learning contexts. Meanwhile, educational agents built on large model capabilities have begun to move from general question answering toward course tutoring, homework support, learning analytics, and personalized guidance. In many university teaching scenarios, AI is no longer merely an extracurricular supplementary tool but has begun to enter the course learning process itself. Recent research has likewise shifted from broad discussions to more specific educational contexts, examining how intelligent tools affect learning support, instructional integration, and educational governance [1–3]. Given this shift, leveraging platform-based intelligent learning support tools to promote more inclusive, accessible, and sustainable education is closely related to Sustainable Development Goal 4 (SDG 4).

In this study, the Chaoxing AI learning companion platform is conceptualized as an agentic system—an AI-enabled learning companion that can interpret students' requests, select appropriate tools and learning resources, and take goal-oriented actions within the course-based learning environment. Depending on the context, this platform is also referred to below as an AI agent, agentic AI, or agent-based learning companion.

Nevertheless, the more diverse the technological forms, the more necessary it is to distinguish the educational functions of different types of tools. Compared with open, general-purpose large models, the Chaoxing AI learning companion platform possesses a stronger education-vertical orientation. It is not a general question-answering system that operates independently of course platforms; rather, it is a platform-based learning support tool embedded in the teaching process together with course resource organization, knowledge graph display, assignment and testing feedback, agent-based question answering, and, in some courses, programming support. For this reason, the value of the Chaoxing AI learning companion platform is more likely to be realized in specific learning activities such as completing assignments, receiving learning feedback, and obtaining problem-solving hints, rather than merely helping students access information more conveniently. This also echoes recent research on generative AI applications in education, which suggests that different technological forms differ in their functional boundaries, usage modes, and pedagogical value [4–5].

This issue is particularly important for vocational education. Vocational learning emphasizes task contexts, application orientation, and problem solving; students need not only to acquire knowledge but also to analyze, judge, reflect, and innovate in complex or simulated professional scenarios. The value of platform-based learning support tools thus lies not only in helping students obtain information more quickly but also in whether they can further promote the development of higher-order thinking. As discussed in this paper, higher-order thinking comprises four dimensions—problem solving, critical analysis, metacognition, and creativity—mainly involving learners' abilities to analyze problems, judge information, regulate learning processes, and generate new ideas in complex tasks.

Although existing research has accumulated a substantial body of discussion on AI and education, several gaps remain; the following three are particularly relevant. First, many studies focus on willingness to use general-purpose large models, ethical controversies, or overall learning perceptions, paying insufficient attention to education-vertical tools embedded in teaching platforms. Second, even when technology acceptance is addressed, many studies remain at the level of attitudes or intentions, rarely asking a further question: whether learners' acceptance of platform functions can translate into higher-level cognitive outcomes, especially higher-order thinking. Existing reviews also indicate that research in this area is dominated by attitudes, intentions, and ethical issues regarding general-purpose generative AI, with relatively limited attention to platform-embedded learning support tools and their learning outcome variables [1, 6]. For vocational college students, a group with a distinctly practice-oriented profile, direct evidence on this issue is still lacking.

## 2. Literature review and research hypotheses

### 2.1. Technology acceptance model and platform-based learning support tools

The Technology Acceptance Model posits that individuals' acceptance of technology is mainly influenced by perceived ease of use and perceived usefulness [7]. The former emphasizes whether a system is easy to learn and operate, whereas the latter emphasizes whether a system helps improve task performance. Subsequent research has further shown that, in educational technology contexts, these two variables have strong explanatory power for learners' acceptance of platforms or systems, although their relative influence varies with technology type, user experience, and usage context [8].

Recent advances in agentic AI have renewed interest in the technology acceptance process. Karran et al. (2025) examined multi-stakeholder acceptability of responsible AI in education and highlighted the role of perceived AI agency in shaping acceptance, while others demonstrated that AI-based pedagogical agents significantly enhance students' self-efficacy, engagement, and learning outcomes in programming education [9]. In adaptive learning environments with motivational pedagogical agents, Su et al. (2025) found that agent-supported learning can support personalized learning and benefit learners with different prior-knowledge levels, and Alshammari et al. (2025) reported that technological, ethical, social, and individual determinants jointly shape GenAI-supported learning beyond simple acceptance [10–11]. These emerging findings jointly suggest that the agentic nature of AI learning companions should be treated as an explicit factor in technology acceptance research alongside perceived ease of use and perceived usefulness.

For platform-based learning support tools, ease of use is certainly important but is not always decisive. For students who have long been exposed to digital platforms, basic usability resembles an entry threshold rather than the core condition determining whether they are willing to continue using a tool. What truly matters is often whether the tool can help them complete tasks, improve learning performance, or enhance the learning experience. In the context of this agent-based learning companion, students' judgments about the platform's educational value are likely to influence their acceptance more than their judgments about the difficulty of operating it. Accordingly, the following hypotheses are proposed:

H1: Perceived ease of use significantly and positively affects vocational college students' acceptance of the Chaoxing AI learning companion platform.

H2: Perceived usefulness significantly and positively affects vocational college students' acceptance of the Chaoxing AI learning companion platform.

## 2.2. Higher-order thinking and platform-based learning support

Higher-order thinking is commonly used to describe cognitive activities that go beyond rote memorization and simple reproduction [12–13]. In this study, higher-order thinking comprises four dimensions: problem solving (PS), critical analysis (CT), metacognition (MN), and creativity (CR). Specifically, problem solving emphasizes identifying problems, analyzing conditions, and proposing solutions; critical analysis focuses on verifying information, comparing viewpoints, and forming well-considered judgments; metacognition centers on planning, monitoring, reflection, and self-correction; and creativity involves breaking through existing paths and generating new ideas and solutions. The higher-order thinking scale adopted in this study draws on four dimensions from a previously validated complex thinking instrument—problem solving, critical analysis, metacognition, and creativity [14].

Relevant research suggests that intelligent learning support tools can help learners analyze problems more systematically, revise their understanding, and regulate their learning processes through immediate feedback, hints, and resource integration; such tools are particularly promising in problem-based learning, case analysis, and task-based learning. However, technical capability does not equal learning outcomes. Whether platform functions genuinely contribute to higher-order thinking largely depends on whether learners are willing to accept those functions and integrate them into their own learning processes. Therefore, the study proposes:

H3: Vocational college students' acceptance of the Chaoxing AI learning companion platform significantly and positively affects their higher-order thinking.

## 2.3. Research gaps and the mediation mechanism

Research on AI applications in education suffers from at least three deficiencies. First, current discussions revolve mainly around general-purpose generative AI, with insufficient attention to learning support tools embedded in educational platforms such as the Chaoxing agent-based companion. Second, vocational education places greater emphasis on task contexts and applied competencies, yet empirical research on vocational college students' use of platform-based learning support tools is relatively limited. Third, existing studies often treat "attitude" or "intention" as the endpoint, rarely examining whether learners' acceptance of a tool extends to higher-level learning outcomes such as problem solving, critical analysis, metacognition, and creativity.

Theoretically, perceived ease of use and perceived usefulness may not directly affect higher-order thinking; rather, they are more likely to operate first on students' acceptance of the platform and then influence cognitive outcomes indirectly through acceptance and subsequent usage processes. In other words, platform acceptance may be a key mechanism linking technology perceptions and higher-order thinking.

Accordingly, the study proposes:

H4: Acceptance of the Chaoxing AI learning companion platform mediates the relationship between perceived ease of use and higher-order thinking.

H5: Acceptance of the Chaoxing AI learning companion platform mediates the relationship between perceived usefulness and higher-order thinking.

Building on this reasoning, this study takes the Technology Acceptance Model as its theoretical foundation, with perceived ease of use and perceived usefulness as antecedent variables, acceptance of the Chaoxing AI learning companion platform as the mediating variable, and higher-order thinking as the outcome variable, and tests the corresponding structural relationships. The study mainly addresses three questions: first, whether perceived ease of use and perceived usefulness affect vocational college students' acceptance of the Chaoxing AI learning companion platform; second, whether platform acceptance affects vocational college students' higher-order thinking; and third, whether platform acceptance mediates the relationships between the antecedent variables and higher-order thinking. The theoretical framework of this study is presented in **Figure 1**.

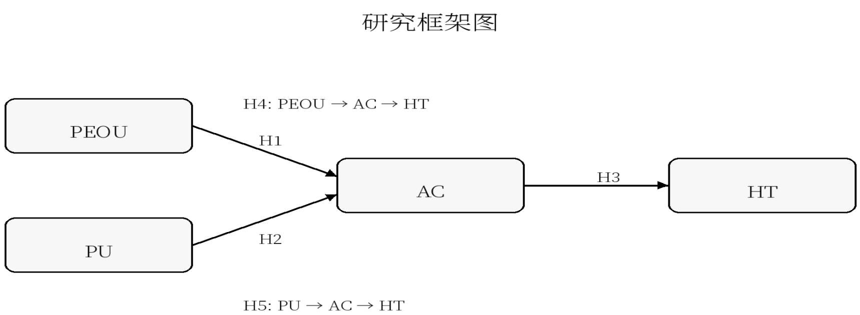


**Figure 1.** Research framework. Note: PEOU = perceived ease of use; PU = perceived usefulness; AC = adoption of the Chaoxing AI learning companion platform; HT = higher-order thinking. HT is reflected by four dimensions: problem solving, critical analysis, metacognition, and creativity.

# 3. Method

## 3.1. Research design and sample

This study employed a cross-sectional questionnaire design. Vocational college students were recruited as the research participants, and their perceptions, acceptance, and higher-order thinking in the context of using the Chaoxing AI learning companion platform were examined. After data collection, questionnaires with obvious careless responding were screened out, and the remaining valid questionnaires were subjected to Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis.

## 3.2. Pretest and formal survey

No separate formal pilot test was conducted in this study, but a small-scale pretest was administered before the formal questionnaire was distributed. Participants generally considered the questionnaire to be moderate in length, clearly worded, and easy to understand. Based on these responses, the basic comprehensibility of the questionnaire was preliminarily confirmed, and the formal survey was subsequently administered.

### 3.3. Variable measurement

The antecedent variables in this study include perceived ease of use (PEOU) and perceived usefulness (PU). PEOU captures whether students see the agentic learning companion as simple to operate, easy to interact with, and quick to learn; PU captures whether they think the platform improves the learning experience, facilitates course learning, and raises task completion efficiency.

The mediating variable is adoption of the Chaoxing AI learning companion platform (AC), measured mainly in terms of overall satisfaction, positive evaluation of the platform's educational potential, and identification with the platform as a supplement to learning tools.

The outcome is higher-order thinking (HT), which in this design comprises four dimensions: problem solving (PS), critical analysis (CT), metacognition (MN), and creativity (CR). This treatment keeps the multidimensional nature of higher-order thinking while letting us examine the relationship between platform acceptance and higher-level cognitive outcomes at the overall level. **Table 1** lists the constructs and their measurement items.

**Table 1.** Constructs and measurement items

| Construct | Description | Sample item content | Source |
|---|---|---|---|
| PEOU | Perceived ease of use | Simple and uncomplicated to operate; easy to learn and become familiar with | Adapted from TAM literature, contextualized to the Chaoxing platform |
| PU | Perceived usefulness | Improved learning experience; facilitated course learning; improved task completion efficiency | Adapted from TAM literature, contextualized to the Chaoxing platform |
| AC | Adoption of the Chaoxing AI learning companion platform | Overall satisfaction; positive evaluation of educational potential; accepted as a supplement to learning tools | Adapted from technology acceptance literature, contextualized to the Chaoxing platform |
| HT | Higher-order thinking | Problem solving, critical analysis, metacognition, creativity | Adapted from higher-order thinking literature, contextualized to the Chaoxing platform |

Note: All items were contextually adapted from existing technology acceptance and higher-order thinking research and adjusted to the usage context of the Chaoxing AI learning companion platform

### 3.4. Data analysis

This study used SmartPLS for partial least squares structural equation modeling (PLS-SEM). Three considerations guided this choice: the sample size is relatively small; the study concerns not only path relationships but also the predictive relevance of the model; and PLS-SEM suits models with multiple reflective constructs and mediating relationships [15]. The analytical procedure consisted of descriptive statistical analysis, measurement model assessment, structural model testing, mediation analysis, and predictive capability assessment.

## 4. Results

### 4.1. Descriptive statistics

A total of 109 raw questionnaires were collected in this study. After excluding straight-lining responses and other obviously careless invalid questionnaires, 75 valid responses were retained for subsequent PLS-SEM analysis. The basic characteristics of the sample are presented in **Table 2**.

**Table 2.** Sample characteristics

| Variable | Category | n | % |
|---|---|---|---|
| Gender | Male | 40 | 53.3 |
| | Female | 35 | 46.7 |
| Grade | Freshman | 34 | 45.3 |
| | Sophomore | 40 | 53.3 |
| | Junior | 1 | 1.3 |
| Major | Business | 36 | 48.0 |
| | STEM | 17 | 22.7 |
| | Other | 16 | 21.3 |
| | Humanities/Arts/Social Sciences | 6 | 8.0 |
| Usage frequency | Weekly | 26 | 34.7 |
| | 1–2 times per semester | 19 | 25.3 |
| | Daily | 19 | 25.3 |
| | More than once a month / as needed | 11 | 14.7 |

Note: N = 75. Because "primary purpose of use" was a multiple-choice question, it is described separately in the text according to endorsement frequencies.

Regarding sample structure, males slightly outnumbered females; in terms of grade level, freshmen and sophomores dominated, with sophomores slightly more numerous. By major, business students accounted for the largest proportion, followed by STEM and other majors. Regarding usage frequency, weekly users were the most numerous, accounting for about one-third; daily users and those who used the platform 1–2 times per semester were equally represented. As for primary purposes, the most common use was completing assignments/practice (69.3%), followed by obtaining supplementary learning materials (60.0%), using the platform because of instructor requirements (60.0%), viewing learning analytics (57.3%), and viewing knowledge graphs (52.0%); the proportion of students who used the platform for direct question-and-answer interaction with AI agents was 28.0%.

## 4.2. Measurement model assessment

After the initial measurement model assessment, a limited revision was made to a small number of items with poor measurement performance or high redundancy. This revision was based on a joint consideration of indicator performance and item meaning, aiming to improve scale quality while preserving the original measurement content as much as possible. After the revision, all core constructs exhibited good internal consistency and convergent validity. Discriminant validity was assessed using the HTMT and Fornell–Larcker criteria [16]. The reliability and convergent validity results of the measurement model are presented in **Table 3**.

**Table 3.** Measurement model results

| Construct | Cronbach's α | rho_A | CR | AVE | Conclusion |
|---|---|---|---|---|---|
| AC | 0.942 | 0.944 | 0.963 | 0.896 | Satisfactory |
| HT | 0.937 | 0.948 | 0.944 | 0.519 | Satisfactory |

| Construct | Cronbach's α | rho_A | CR | AVE | Conclusion |
|---|---|---|---|---|---|
| PEOU | 0.906 | 0.913 | 0.941 | 0.843 | Satisfactory |
| PU | 0.883 | 0.893 | 0.945 | 0.895 | Satisfactory |

Note: All constructs have CR above 0.70 and AVE reaching or exceeding 0.50, indicating good internal consistency and convergent validity.

During the revision process, CR3 and CR4 in the creativity dimension were not retained because of low outer loadings (loadings<0.7), and PU2 in perceived usefulness was deleted because of strong redundancy with other indicators of the same construct. The proportion of deleted items was small, representing a cautious scale purification. The two retained PU items still correspond to overall learning gains and task completion efficiency, respectively, preserving the core meaning of the construct. In addition, a small number of items with relatively low outer loadings but content representativeness were retained in the final model. Although the loadings of MN4 (0.466) and PS2 (0.568) were relatively low, the AVE of the relevant constructs still reached acceptable standards; these items were therefore retained on the basis of a balance between statistical results and content completeness.

In this study, discriminant validity was established through both the Fornell–Larcker criterion and the heterotrait–monotrait ratio (HTMT). First, the square root of the average variance extracted (AVE) of each latent variable was greater than its correlations with any other latent variable, satisfying the Fornell–Larcker criterion [16]. In addition, all HTMT values were below the lenient threshold of 0.90, providing further support for discriminant validity [17]. The discriminant validity results are presented in **Tables 4** and **5**.

**Table 4.** Discriminant validity results: Fornell–Larcker criterion

| Construct | AC | HT | PEOU | PU |
|---|---|---|---|---|
| AC | 0.946 | | | |
| HT | 0.540 | 0.721 | | |
| PEOU | 0.682 | 0.372 | 0.918 | |
| PU | 0.820 | 0.493 | 0.788 | 0.946 |

Note: Diagonal values are the square roots of the AVE of each construct.

**Table 5.** Discriminant validity results: HTMT matrix

| Construct | AC | HT | PEOU | PU |
|---|---|---|---|---|
| AC | — | | | |
| HT | 0.551 | — | | |
| PEOU | 0.738 | 0.396 | — | |
| PU | 0.895 | 0.527 | 0.881 | — |

Note: HTMT values below the threshold of 0.90 indicate acceptable discriminant validity [17].

The collinearity check showed that the inner-model VIF values were PEOU→AC = 2.643, PU→AC = 2.643, and AC→HT = 1.000, indicating no serious structural collinearity problems.

## 4.3. Structural model results

The structural path results are presented in **Table 6**, and the path coefficients and significance of the structural model are shown in **Figure 2**.

**Table 6.** Structural path results

| Hypothesis | Path | β | t | p | Significance | Result |
|---|---|---|---|---|---|---|
| H1 | PEOU → AC | 0.092 | 0.648 | 0.517 | ns | Not supported |
| H2 | PU → AC | 0.748 | 4.970 | < 0.001 | *** | Supported |
| H3 | AC → HT | 0.540 | 4.921 | < 0.001 | *** | Supported |

Note: ns = not significant; *** $P < .001$.

The results show that perceived ease of use did not significantly affect platform acceptance; thus, H1 was not supported. Perceived usefulness had a significant positive effect on platform acceptance, supporting H2. Platform acceptance also had a significant positive effect on higher-order thinking, supporting H3.

In terms of explanatory power, the $R^2$ of AC was 0.676, indicating that perceived ease of use and perceived usefulness strongly explain platform acceptance; the $R^2$ of HT was 0.292, indicating that platform acceptance explains higher-order thinking to a certain extent. Regarding effect sizes, the $f^2$ of PEOU→AC was 0.010, indicating a weak effect; the $f^2$ of PU→AC was 0.654, indicating a strong effect; and the $f^2$ of AC→HT was 0.412, also reaching a strong level. Supplementary fit indices showed SRMR = 0.097 and NFI = 0.593. Given that PLS-SEM emphasizes prediction and path explanation, these fit indices are reported as supplementary information only.

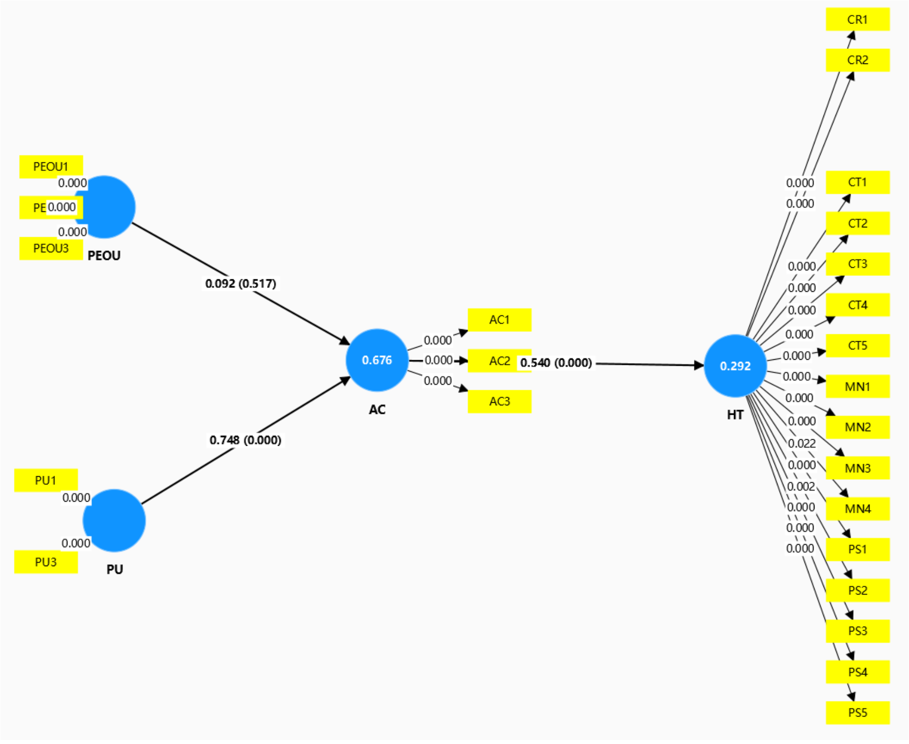


**Figure 2.** Structural model with path coefficients and significance. Note: Values in circles are the $R^2$ of endogenous variables; values beside paths are standardized path coefficients, with $P$ values in parentheses; values beside observed indicators are the outer model significance results.

### 4.4. Mediation results

The mediation results are presented in **Table 7**.

**Table 7.** Mediation results

| Hypothesis | Indirect path | β | t | p | Significance | Result |
|---|---|---|---|---|---|---|
| H4 | PEOU → AC → HT | 0.050 | 0.618 | 0.537 | ns | Not supported |
| H5 | PU → AC → HT | 0.404 | 3.314 | 0.001 | ** | Supported |

Note: ns = not significant; ** $P < .01$.

The results show that the indirect effect of perceived ease of use on higher-order thinking through platform acceptance was not significant, so H4 was not supported; the indirect effect of perceived usefulness on higher-order thinking through platform acceptance was significant, supporting H5. In line with the theoretical rationale that perceptions of an AI learning companion affect higher-order thinking only after students accept and engage with the platform, platform acceptance was specified as the sole transmission mechanism in the initial model; therefore, no direct paths from perceived ease of use or perceived usefulness to higher-order thinking (PEOU→HT / PU→HT) were included.

### 4.5. Predictive capability results

The prediction results show that the $Q^2$_predict of AC was 0.640 and that of HT was 0.186, both greater than zero, indicating that the model has predictive relevance for both endogenous constructs, with stronger predictive relevance for platform acceptance. Compared with the linear model, the PLS model did not show a clear advantage for AC but showed better predictive performance for HT. The model thus demonstrates limited but acceptable predictive capability, with modest predictive value particularly for the outcome variable of higher-order thinking. The predictive assessment results are presented in **Table 8**.

**Table 8.** Predictive assessment results

| Construct | $Q^2$_predict | Comparison with LM | Predictive judgment |
|---|---|---|---|
| AC | 0.640 | Not overall superior to the linear model | Strong predictive relevance, but limited incremental predictive advantage |
| HT | 0.186 | Overall superior to the linear model | Some predictive capability |

Note: A $Q^2$_predict greater than zero indicates that the model has predictive relevance.

## 5. Discussion

The results show that perceived usefulness significantly affects vocational college students' acceptance of the Chaoxing AI learning companion platform, whereas the effect of perceived ease of use does not reach significance; platform acceptance is, in turn, significantly and positively associated with higher-order thinking and exerts a significant indirect effect between perceived usefulness and higher-order thinking.

The prominence of perceived usefulness fits the usage context of the Chaoxing platform. For students, the value of the platform lies not in the technical concept itself but in whether it can satisfy immediate learning needs for on-demand help and quick mastery of course content; the AI learning companion is a support system embedded in course-based learning processes rather than an isolated question-answering tool. Students who receive direct help with assignments, review, course comprehension, or task advancement usually form a more positive acceptance. In the vocational education context, a platform perceived as useful may therefore connect more strongly with learners' acceptance and, through it, with higher-order thinking gains than one perceived as easy to use.

Second, the relationship between platform acceptance and higher-order thinking is also easy to understand in how students actually use the Chaoxing platform. Knowledge graphs, for instance, help students organize fragmented knowledge into associative networks; this structured presentation fits associative processing in the brain and may support problem solving and creative thinking. The AI agents give 24/7 learning companion support, so students can get timely hints, clarification, or extra explanations when they encounter questions; this immediacy keeps learning continuous and may promote analysis and reflection [18]. Through repeated question–answer–reflection cycles, students may gradually internalize the underlying structure of a problem; these moments of insight are the higher-order cognitive gains this study set out to capture.

Third, an intelligent assignment-grading function may also shape higher-order thinking. Compared with providing a result in one go, timely feedback, error-correction hints, and subsequent optimization suggestions are more likely to prompt students to revisit their reasoning, identify where errors occurred, and adjust their approaches. This cycle resembles the monitoring, reflection, and revision involved in metacognition and may also be helpful for critical analysis. For vocational college students, learning outcomes often depend on whether they can continuously improve their practices in response to feedback.

In addition, code-tutoring functions on the Chaoxing platform may also relate to the logical training behind higher-order thinking. For beginners with weak programming foundations, these functions do not replace thinking; they help students understand steps, organize logic, and lower the entry threshold. That novices can get started easily does not mean that cognitive demands are weakened; on the contrary, with appropriate scaffolding in code generation, error explanation, and problem-solving hints, the platform can help students gradually build clearer logical chains and more flexible problem-solving approaches.

In this study, the low, nonsignificant effect of perceived ease of use has several possible explanations. First, as digital natives, current students already know how to operate platform-based technologies and treat ease of use almost as a taken-for-granted prerequisite rather than a decisive condition for acceptance. Second, the platform has many functions, but its interface hierarchy, menu settings, or functional entry points may be relatively complex, so students may not have formed a strong ease-of-use perception; a clearer, friendlier, lower-cognitive-load interface might help. Sample size also matters: the sample is small and concentrated in one group, so this result may not fully reflect ease-of-use perceptions among a broader student population; larger samples are needed.

The mediation results further indicate that whether the platform is genuinely accepted by students may be a key link connecting technology perceptions and higher-order thinking. Even when students see the platform as helpful, that judgment does not automatically become higher-level learning; benefits for higher-order thinking are more likely to appear when this perception of usefulness turns into sustained use and integration into learning processes. The platform's educational value thus builds gradually through perception, acceptance, use, and reflection, rather than being decided directly by the mere existence of functions.

These results have practical implications as well. Institutions and instructors promoting the platform should explain concretely how its functions serve course learning (e.g., immediate help, assignment revision, knowledge organization, and code tutoring), rather than emphasizing the number of functions or the novelty of the technology. For platform designers, improving interface friendliness and functional accessibility matters as much as strengthening the learning-support value of functions, so students can find, understand, and keep using relevant functions. If students see the platform as both genuinely helpful and smoother to use, its support for higher-order thinking may become easier to observe.

## 6. Limitations and future research

First, the sample of 75 valid questionnaires was drawn from a single vocational college, which limits the statistical power of the path tests and the generalizability of the findings. Future research should expand the sample size and recruit participants from multiple vocational colleges across different regions to enhance the robustness and external validity of the model.

Second, the cross-sectional questionnaire design and self-reported measures may introduce common method bias and do not permit causal inferences. Future studies could adopt longitudinal tracking, experimental or quasi-experimental designs, and objective behavioral data to provide stronger evidence for the causal relationships identified here.

Third, although the structural model exhibited acceptable predictive relevance ($Q^2$_predict > 0), the overall model fit indices were moderate (e.g., SRMR = 0.097 and NFI = 0.593), and the HTMT value between perceived usefulness and acceptance (0.895) approached the threshold of 0.90. Future work may refine the measurement model, introduce additional mediators or moderators, or cross-validate the findings with covariance-based structural equation modeling.

## 7. Conclusion

Based on the Technology Acceptance Model, this study examined how the Chaoxing AI learning companion platform influences vocational college students' higher-order thinking. The results show that perceived usefulness, rather than perceived ease of use, significantly drives platform acceptance, which in turn is positively associated with higher-order thinking and mediates the usefulness–thinking relationship. Thus, in the vocational education context, whether a platform-based AI learning support tool can function may depend less on how easy it is to operate than on whether students genuinely perceive its help with learning tasks. These findings extend TAM to embedded AI learning companion scenarios and provide a practical reference for vocational colleges to improve platform design and promote quality-oriented, sustainable education (SDG 4).

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## Disclosure statement

The authors declare no conflict of interest.

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